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COSTS OF WASTEWATER RENOVATION

Robert Smith

Environmental Protection Agency
Cincinnati, Ohio

November 1971

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ENVIRONMENTAL PROTECTION AGENCY
Office of Research and Monitoring
Advanced Waste Treatment Research Laboratory
Cincinnati, Ohio

November 1971

The use of renovated wastewater to supplement raw water sources is widely accepted and has been shown to be a least cost alternative in many cases. Closed cycle reuse, of course, will never be possible because make-up water will be needed to replace water used consumptively. In water short areas, the consumptive losses often amount to 50% of the water supply, due to evaporation from storage ponds or lawn watering. Make-up water is also needed to avoid build-up of contaminants in the water system. Figure 1 shows the build-up in TDS to be expected with various amounts of make-up water when no demineralization process is used.

The cost of supplying water to municipalities, industry, and agriculture is composed of many components. The total cost of water supply can be divided into the cost of raw water supply, the cost of water treatment, and the cost of distribution. Similiarly, the cost of wastewater disposal, which should ideally be considered as an integral part of the water supply system, can also be divided into the cost of collection, the cost of wastewater treatment, and the cost of interceptors and outfalls. Administrative cost is, of course, associated with both supply and disposal.

The cost of treatment for use, reuse, or disposal are strongly dependent on the size of the treatment plant, the specific processes used, the excess capacity existing at the plant, the region of the country in which the plant is located and the point in time at which the cost estimates apply. A set of cost indexes by which capital and operating and maintenance cost can be adjusted to any time point is attached.

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FRACTION OF WASTEWATER WHICH CAN BE
REUSED BEFORE DEMINERALIZATION IS REQUIRED

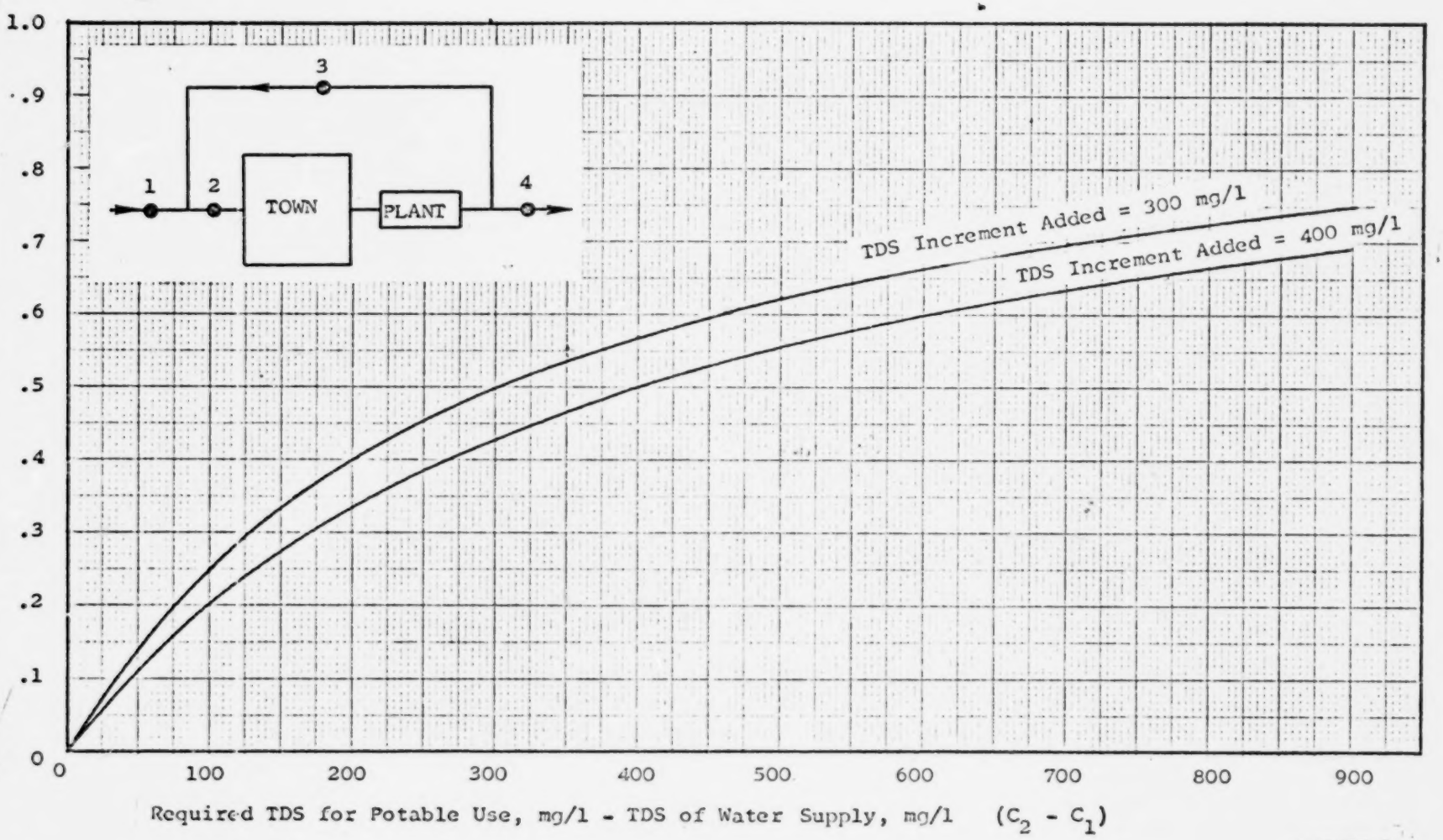

FIGURE 1

The kinds of facilities normally used for water supply are listed in Table I, with estimates of the capital and operating and maintenance cost. The total cost of delivered potable water will be determined by the particular set of these facilities used. Water supply facilities are normally operated as a utility and the cost of delivered water is adjusted to recover the cost incurred, plus some nominal profit. Wastewater treatment facilities, on the other hand, are normally operated by the municipal government and the sewerage user charges are usually less than the true cost of wastewater collection and treatment.

Estimates of the cost of various components associated with wastewater treatment existing in 1968 are shown in Table II. From this table, we can see that the cost of treatment is only about 25% of the total cost to the consumer. The total cost was estimated as $19.80 per capita per year or 54.2 ¢/Kgal, based on 100 gal/capita/day. These costs are in terms of the population served, which was about 140 million in 1968. The fraction of the population served by water and wastewater treatment systems is shown as a function of time in Figure 2.

The cost of wastewater treatment plants for disposal to a receiving stream can be estimated from historical data available from the construction grants program of EPA or the cost of a plant can be computed from the experienced cost of the various processes installed at the plant. To show the importance of the specific processes used in making a cost estimate, Figures 3 and 4 are attached which show the cost of a secondary activated sludge plant with two alternative sets of sludge handling processes.

TABLE I

COST OF WATER SUPPLY FACILITIES - DESIGN CAPACITY OF PLANT - 1 MGD

Estimates for January, 1970 WATER SUPPLY FACILITIES	Construction Cost, millions of dollars	Level Debt Service, cents/1000 gal. 6%, 25 yr.	Operating and Maintenance Cost, cents/1000 gal.	Total Treatment Cost, cents/1000 gal.
WATER SUPPLY:				
Impounding Reservoir (.12 billion gal.)	.34	7.3	5.0	12.3
Well Supply (0.86 mgd)	.41	8.8	6.7	15.5
Intake and Pumping (1.44 mgd)	.069	1.5	5.0	6.5
5 MILE TRANSMISSION PIPELINE (1.4 mgd)	.30	6.4	.31	6.7
PIPELINE PUMPING STATION (1.44 mgd)	.11	2.4	3.7	6.1
RAW WATER STORAGE (10 mg)	.11	2.4	.23	2.6
TREATMENT AND STORAGE (1 mgd)				
Well Supply	.302	6.4	12.	18.4
Flowing River Supply	.302	6.4	13.3	19.7
Softening Required	.302	6.4	15.1	21.5
TREATED WATER PUMP STATION (1.44 mgd)	.066	1.4	4.8	6.2

Source: "Standardized Procedure for Estimating Costs of Conventional Water Supplies", Office of Saline Water, U.S. Dept. of Interior

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TABLE I - Page 2

COST OF WATER SUPPLY FACILITIES - DESIGN CAPACITY OF PLANT - 10 MGD

Estimates for January, 1970 WATER SUPPLY FACILITIES	Construction Cost, millions of dollars	Level Debt Service, cents/1000 gal. @ 25 yr.	Operating and Maintenance Cost, cents/1000 gal.	Total Treatment Cost, cents/1000 gal.
WATER SUPPLY:				
Impounding Reservoir (3.3 bg)	2.74	5.9	3.2	9.1
Well Supply (8.3 mgd)	.295	.63	5.0	5.6
Intake and Pumping (15.4 mgd)	.501	1.07	3.2	4.3
5 MILE TRANSMISSION PIPELINE (13.8 mgd)	.823	1.76	.09	1.9
PIPELINE PUMPING STATION (15.4 mgd)	.487	1.04	1.93	3.0
RAW WATER STORAGE (100 mg)	.70	1.50	.15	1.7
TREATMENT AND STORAGE (10 mgd)				
Well Supply	1.58	3.39	4.9	8.5
Flowing River Supply	1.58	3.39	7.7	11.1
Softening Required	1.58	3.39	9.4	12.8
TREATED WATER PUMP STATION (15.4 mgd)	.357	.77	3.1	3.9

Source: "Standardized Procedure for Estimating Costs of Conventional Water Supplies," Office of Saline Water, U. S. Dept. of Interior

COST OF WATER SUPPLY FACILITIES - DESIGN CAPACITY OF PLANT - 100 MGD

Estimates for January, 1970 WATER SUPPLY FACILITIES	Construction Cost, millions of dollars	Level Debt Service, cents/1000 gal, 6% 25 yr.	Operating and Maintenance Cost, cents/1000 gal.	Total Treatment Cost, cents/ 1000 gal.
WATER SUPPLY:				
Impounding Reservoir (10 bg)	5.42	1.16	2.5	3.7
Well Supply (85 mgd)	2.92	.63	4.2	4.8
Intake and Pumping (100 mgd)	2.50	.54	2.5	3.0
5 MILE TRANSMISSION PIPE-LINE (122 mgd)	2.26	.48	.03	.51
PIPELINE PUMPING STATION (100 mgd)	2.33	.50	1.2	1.7
RAW WATER STORAGE (1000 mg)	6.04	1.29	.13	1.4
TREATMENT AND STORAGE (100 mgd)				
Well Supply	8.99	1.92	4.6	6.5
Flowing River Supply	8.99	1.92	5.9	7.8
Softening Required	8.99	1.92	7.6	9.5
TREATED WATER PUMP STATION (100 mgd)	1.92	.41	2.3	2.7

Source: "Standardized Procedure for Estimating Costs of Conventional Water Supplies," Office of Saline Water, U. S. Dept. of Interior

TABLE I - Page A

COST OF WATER TREATMENT

	Capital Cost, millions of dollars	Level Debt Service, cents/1000 gal. 6%, 25 yr.	Operating and Maintenance Cost, cents/1000 gal.	Total Treatment Cost, cents/1000 gal.
Water Treatment: flocculation, sedimentation, filtration, chlorination				
1 mgd Design Capacity	.43	9.2	7.92	17.1
10 mgd Design Capacity	1.99	4.3	4.59	8.9
100 mgd Design Capacity	5.62	1.2	1.20	2.4

Source: Orlob and Lindorf "Cost of Water Treatment in California," Journal of AWWA, January, 1958.

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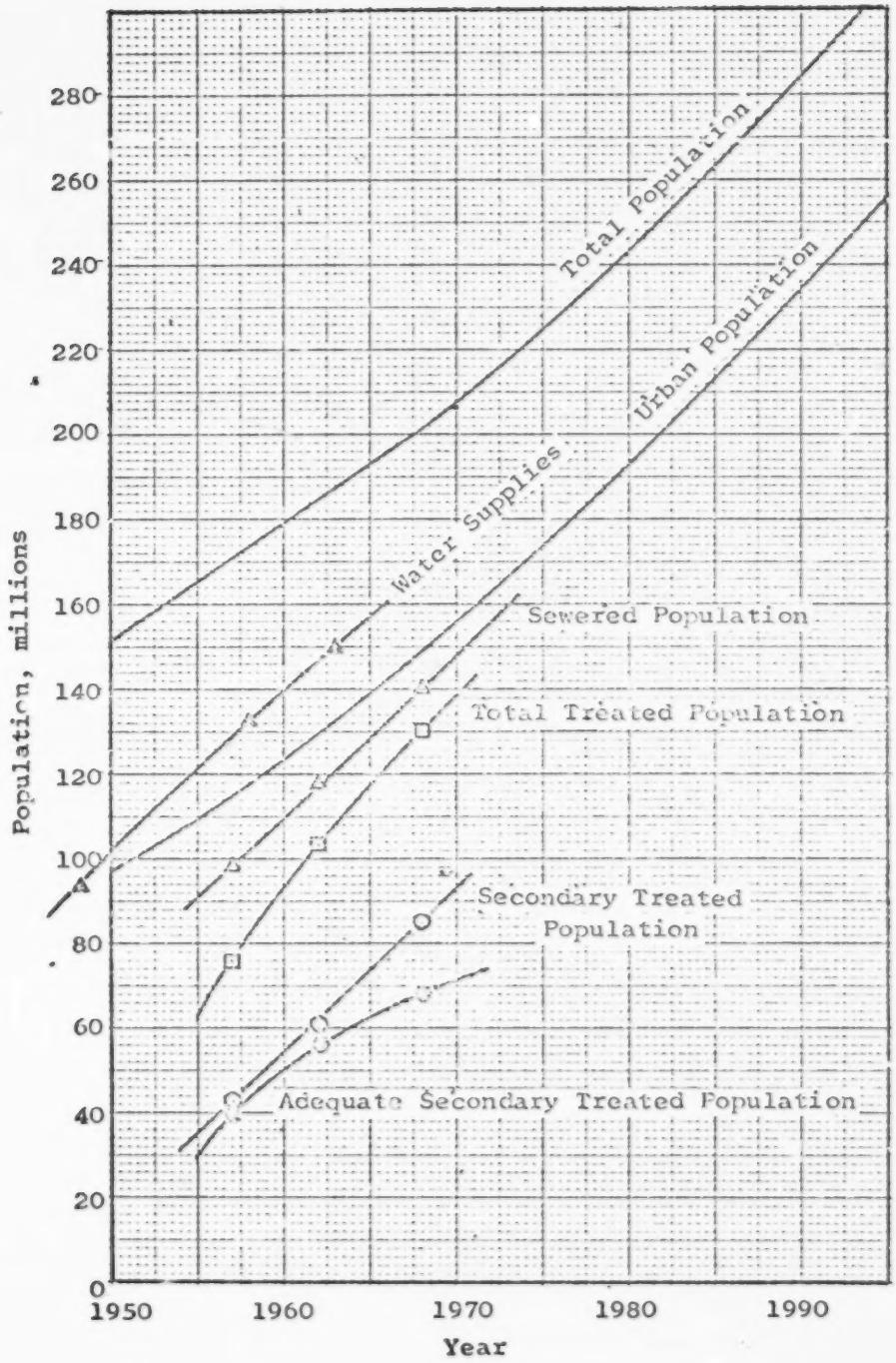
TABLE II

TOTAL COST OF SEWAGE COLLECTION AND TREATMENT IN 1968
ON A CONTINUOUS CASH FLOW BASIS

1968 dollars/capita/year

Amortization Cost		
House Connection	$1.38	
Municipal Sewers	$8.64	
Interceptors and Outfalls	$2.46	
Treatment Plants	$2.83	
Total Amortization Cost	$15.31	
Current Expenses		
Municipal Sewer Maintenance		$0.86
Treatment Operation and Maintenance		$1.55
Customer Service and Accounting		$0.71
General and Administrative		$1.37
Total Current Expenses		$4.49
Total Cost of Municipal Collection and Treatment	$19.80	

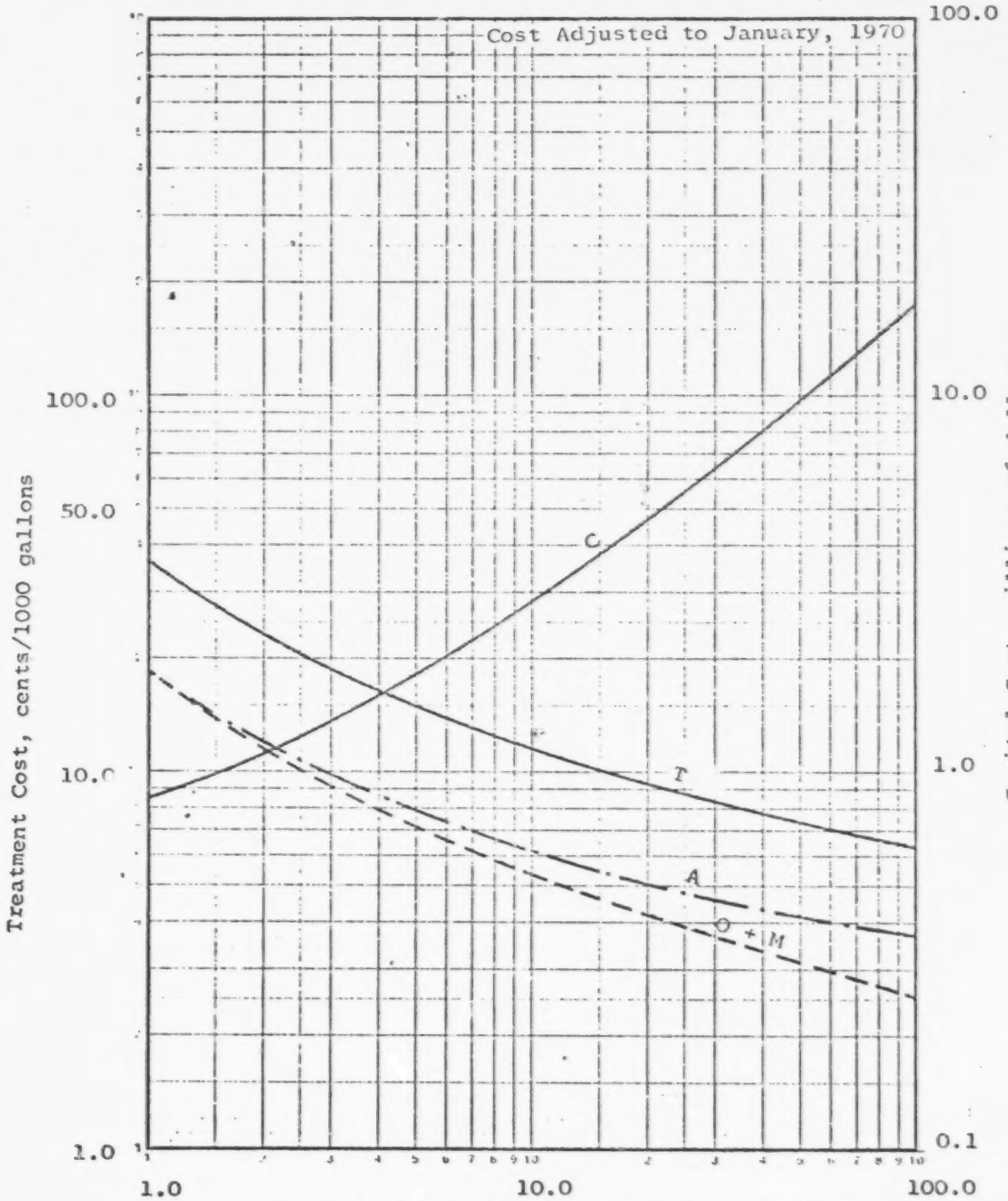


STATUS OF MUNICIPAL WASTEWATER TREATMENT FACILITIES IN THE UNITED STATES

FIGURE 2

ACTIVATED SLUDGE PLANTS

Including: Raw Sewage Pumps, Preliminary Treatment-G+F+S, Primary Sedimentation, Primary Sludge Pumps, Aerators, Diffused Air System, Final Settlers-Multiple, Recirculation Pumps, Sludge Thickener, Anaerobic Digesters, Sludge Drying Beds, Chlorination, Laboratory

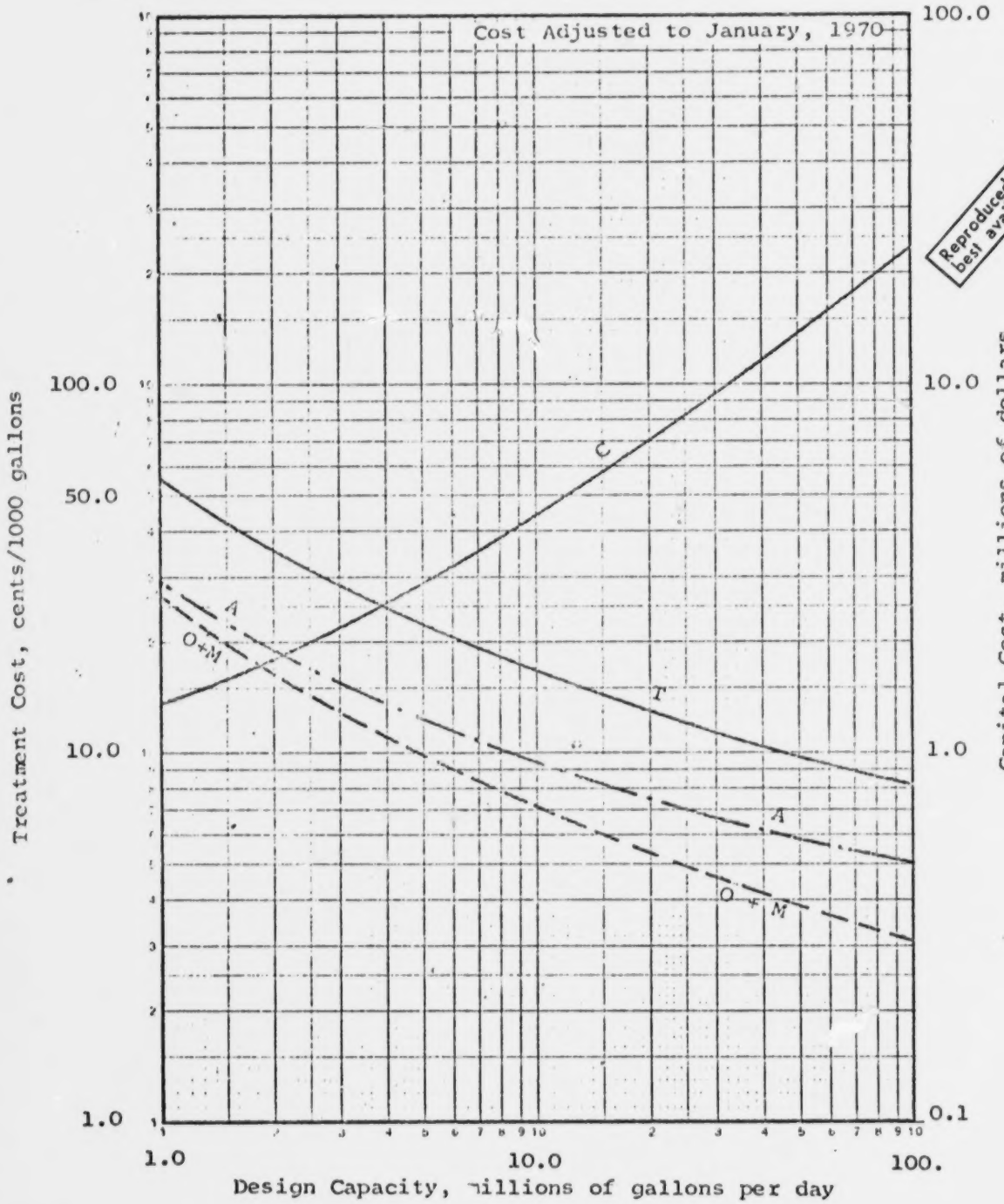


C = Capital Cost, millions of dollars
A = Debt Service, cents per 1000 gallons (6% - 25 yr.)
O + M = Operating and Maintenance Cost, cents per 1000 gallons
T = Total Treatment Cost, cents per 1000 gallons

FIGURE 3

ACTIVATED SLUDGE PLANTS

Including: Raw Sewage Pumps, Preliminary Treatment-G+F+S, Primary Sedimentation, Primary Sludge Pumps, Aerators, Diffused Air System, Final Settlers-Multiple, Recirculation Pumps, Sludge Thickener, Anaerobic Digesters, Sludge Holding Tanks, Vacuum Filtration, Multiple Hearth Incineration, Chlorination, Laboratory



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C = Capital Cost, millions of dollars
A = Debt Service, cents per 1000 gallons (6% - 25 yr.)
O + M = Operating and Maintenance Cost, cents per 1000 gallons
T = Total Treatment Cost, cents per 1000 gallons

FIGURE 4

The total cost of water supply systems is not known with precision, but the average cost of delivered water in 1955 was reported by Seidel and Baumann[1] as $2.75 per 1000 cu. ft. This is equivalent to 36.8 cents/Kgal in terms of 1955 dollars. If we adjust this number to 1968 prices, the cost of delivered water would be 47.8 cents/Kgal. Koenig[2] (1966) found the cost of water in an 8 mgd plant to be 14.39 cents/Kgal for treatment alone. The total cost of delivered potable water has been estimated in Committee Print No. 7[3] to consist of 19% source development, 22% treatment, and 59% distribution. The average consumption per person, including industrial uses was found to be 137 gal/day/person in 1955. If we assume 150 gal/day/person for municipal and industrial supply, the average cost per capita for water supply would be $26.17 per capita per year. The average domestic consumption of water in 1955, however, was only 61 gal/day/capita according to Seidel and Baumann. The cost of water to the average household would, therefore, be about $10.64/capita/year. U. S. Department of Commerce statistics[4] on water utilities (1968) give the average per capita cost of water supply as $16.44 per capita per year and the revenue as $16.10 per capita per year. In general, we can conclude that the cost of water supply is normally somewhat less than the cost of wastewater treatment.

The cost of wastewater renovation processes are shown in Table III. The level debt service cost is computed, based on paying interest at 6% on the unpaid balance, plus a payment on the principal which will pay the total capital cost back to the bond holders over a 25 year period. Plants are normally sized to be adequate for the served population at the end of

WASTEWATER TREATMENT FOR REUSE, NATIONAL AVERAGE, JANUARY, 1970, 1 mgd DESIGN CAPACITY

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PROCESSES USED	Capital Cost, millions of dollars	Level Debt Service, cents/1000 gal, 6% 25 yr.	Operating and Maintenance Cost, cents/1000 gal.	Total Treatment Cost, cents/1000 gal.	Effluent Concentration, mg/l											
					COD	50	30	22	22	5	5	10				
					Phosphorus	10	8	.2	.2	.2	.5	8				
					Nitrogen	20	19	18	15	8	5	18				
					TDS	1000	1000	1000	1000	500	200	1000				
Conventional Treatment	.85	18.0	18.0	36.0		○	○	○	○	○	○	○				
Separate Nitrification	.22	4.8	6.7	11.5					○	○						
Lime Clarification	.14	2.8	8.4	11.2				○	○	○						
Filtration	.10	2.2	4.6	6.8			○	○	○	○	○					
Carbon Adsorption	.40	8.6	23.7	32.3						○		○				
Ion Exchange	.23	4.9	18.0	22.9			Agricultural	Industrial	Recreational	○	Potable	Potable				
Electrodialysis	.57	12.2	14.5	26.7						Potable						
Reverse Osmosis	.50	10.7	27.1	37.8							○					
Chlorination	.05	.94	1.34	2.3			○	○	○	○	○	○				
Brine Disposal (Evaporation Ponds)	.33	7.1	.68	7.8												
Total Capital Cost, millions of dollars						0	.15	.29	.51	1.14	.65	.45				
Total Treatment Cost, cents/1000 gal.						0	9.1	20.3	31.8	37.0	46.9	35.4				

TABLE III

WASTEWATER TREATMENT FOR REUSE, NATIONAL AVERAGE, JANUARY, 1970 10 mgd DESIGN CAPACITY

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PROCESSES USED	Capital Cost, millions of dollars	Level Debt Service, cents/1000 gal., 6% 25 yr.	Operating and Maintenance Cost, cents/1000 gal.	Total Treatment Cost, cents/1000 gal.	Effluent Concentration, mg/l										
					COD	50	30	22	22	5	5	10			
					Phosphorus	10	8	.2	.2	.2	.5	8			
					Nitrogen	20	19	18	15	8	5	18			
					TDS	1000	1000	1000	1000	500	200	1000			
Conventional Treatment	2.85	6.1	5.4	11.5		○	○	○	○	○	○	○			
Separate Nitrification	1.02	2.3	1.7	4.0					○	○					
Lime Clarification	1.44	3.1	5.3	8.4				○	○	○					
Filtration	.47	1.0	2.0	3.0			○	○	○	○	○				
Carbon Adsorption	1.7	3.6	7.2	10.8						○		○			
Ion Exchange	1.45	3.1	13.0	16.1			Agricultural	Industrial	Recreational	○	Potable	Potable			
Electrodialysis	2.9	6.2	10.8	17.0						Potable					
Reverse Osmosis	3.9	8.4	22.0	30.4							○				
Chlorination	.115	.24	.62	.86			○	○	○	○	○	○			
Brine Disposal (Evaporation Ponds)	2.97	6.4	.61	7.0											
Total Capital Cost, millions of dollars						0	.59	2.0	3.1	6.2	4.49	1.82			
Total Treatment Cost, cents/1000 gal.						0	3.86	12.3	16.3	43.2	34.3	11.7			

WASTEWATER TREATMENT FOR REUSE, NATIONAL AVERAGE, JANUARY, 1970 100 mgd DESIGN CAPACITY

PROCESSES USED	Capital Cost, millions of dollars	Level Debt Service, cents/1000 gal., 6% 25 yr.	Operating and Maintenance Cost, cents/1000 gal.	Total Treatment Cost, cents/1000 gal.	Effluent Concentration, mg/l										
					COD	50	30	22	22	5	5	10			
					Phosphorus	10	8	.2	.2	.2	.5	8			
					Nitrogen	20	19	18	15	8	5	18			
					TDS	1000	1000	1000	1000	500	200	1000			
Conventional Treatment	17.2	3.7	2.6	6.3		○	○	○	○	○	○	○			
Separate Nitrification	6.2	1.35	.65	2.0					○	○					
Lime Clarification	7.2	1.6	3.4	5.0				○	○	○					
Filtration	2.1	.5	.9	1.4			○	○	○	○	○				
Carbon Adsorption	12.2	2.6	4.6	7.2						○		○			
Ion Exchange	9.0	1.9	9.0	10.9			Agricultural	Industrial	Recreational	○	Potable	Potable			
Electrodialysis	14.8	3.17	8.06	11.23						Potable					
Reverse Osmosis	31.0	6.6	21.0	27.6							○				
Chlorination	.43	.01	.32	.33			○	○	○	○	○	○			
Brine Disposal (Evaporation Ponds)	26.5	5.7	.54	6.2											
Total Capital Cost, millions of dollars						0	2.5	9.7	15.9	37.1	33.5	12.6			
Total Treatment Cost, cents/1000 gal.						0	1.7	6.7	8.7	26.8	29.3	7.5			

the design period (25 year.) The average ratio between design capacity and population served in the U. S. is about 1.5. The design capacity ratio is known to vary with the region of the country. The operating and maintenance cost shown is based on the assumption that the plant is operating at the design capacity. Many operating and maintenance cost components should ideally be based on the actual amount of water treated, instead of the design capacity. In general, the values shown in Table III tend to be low because they do not provide for a design capacity ratio and because the operating and maintenance costs are based on the design capacity of the plant instead of the actual flow treated.

The cost of wastewater treatment for reuse will depend primarily on the set of processes used. Various possible sets of processes are shown in Table III with the capital and total treatment cost. For agricultural use, secondary effluent can be used without additional treatment in some cases. Multi-media filtration followed by chlorination would represent the maximum treatment needed. The quality of water needed for industrial use can vary from no additional treatment (cooling water for steel mills) beyond secondary.to the highest grade of water including demineralization for the electronic industry. One intermediate industrial treatment train is shown in Table III. For potable use the minimum treatment would probably be nitrification of ammonia nitrogen in the activated sludge process or in a separate process followed by granular carbon adsorption and disinfection. This water would probably be suitable for pumping underground into an aquifer used as the raw potable supply. For direct reuse, separate nitrification followed by lime clarification, multi-media filtration,

granular carbon adsorption and disinfection might be required. As shown by Figure 1, demineralization will probably be needed in only a small fraction of the reuse schemes used.

Since wastewater renovation for reuse must be considered as an alternative to new sources of raw water, the cost of raw water will be an important factor in deciding if reuse is cost/effective. The cost of raw water supply, as used here, is the cost of having the water available at the intake to the water system. This would normally include payments to the owner of the water, plus the cost of transporting the water to the water system inlet. For example: The Texas Water Plan[5] provided for diverting Mississippi River water and delivering the water to various points within the state of Texas. The Texas Water Plan provided for two major canals, the Trans-Texas canal and the Coastal Canal. By the year 2020, it is planned that this system will deliver a total of 17.28 million acre feet of Mississippi River water to points within Texas. The total capital cost of the project has been estimated as 8,996 million dollars based on 1967 levels. Electrical power for pumping required has been estimated as 6.9 million kilowatts. Amortizing this capital cost over 50 years at 4% interest and taking the cost of electrical power as 0.33 cents/KwHr, the average cost of delivered water would be $35.77 per acre-foot. The cost of delivering the water to the eastern Texas border has been estimated as $3.50 per acre-foot. The total cost of water delivered to points within Texas is, therefore, $39.27 per acre-foot in terms of 1967 dollars. This is equivalent to 12.1 cents/Kgal in 1967 dollars or 14 cents/Kgal in terms of January, 1970 dollars. Since no provision has been made for operating and administrative manpower, the cost will be somewhat higher than this value.

The Metropolitan Water District of California (M.P.D.) has been transporting and treating Colorado River water for use in Southern California communities for 30-40 years. The cost of municipal water delivered by M.W.D. in fiscal year 1971-72 to Los Angeles was $48 per acre-foot for untreated water (14.7 cents/Kgal), $53 per acre-foot for filtered water and $57 per acre-foot for filtered and softened water. Water for agricultural purposes was sold in fiscal 1971-72 for $22 per acre-foot untreated (6.8 cents/Kgal), $27 per acre-foot filtered, and $31 per acre-foot filtered and softened. To encourage the use of water for replenishment of underground aquifers, this water was made available by M.W.D. for $24 per acre-foot raw (7.4 cents/Kgal), $29 per acre-foot filtered and $33 per acre-foot filtered and softened. The announced increase over the coming two year period will be $4 per acre-foot per year for untreated municipal water.

The Los Angeles area will also have available about two million acre-feet per year from the new California State Canal which will bring state water from north of the San Francisco area (Feather River) to Southern California. The TDS of Feather River water is about 220 ppm. The estimated true cost of this water is about $85 per acre-foot. The marginal cost of water which would roughly represent pumping power is $15 per acre-foot. It should be emphasized that the cost of M.W.D. water is partially financed out of state taxes. The rule followed is to charge one-third of the cost to taxes and two-thirds to user charges. The average TDS of Colorado River water is 809 ppm. Most of the City of Los Angeles is now being served by the Los Angeles-Owens River Aqueduct bringing 200 ppm TDS water from the Owens River.

The TDS of state water is about 220 ppm. If reclaimed water is used as a substitute for state water, the value of the two waters cannot be reasonably compared on a simple volumetric basis. One study has recommended the concept of a penalty charge of $3.78/acre-foot/100 mg/l of TDS. Thus, if reclaimed water were produced with 500 mg/l TDS, the value of the water would be the production cost, minus $11.34/acre-foot.*

The cost of M.W.D. water is the cost to the water utility. In Los Angeles this is the Department of Water and Power. The most reasonable assumption is to compare the cost of Colorado River water to the cost of renovated water at the 100 mgd water renovation plant.

The cost of conveyance of water can be important if the distances are long. In Table I, for example, the cost of the pumping station is given as 6.1 cents/Kgal and the cost of the pipeline is 1.34 cents/Kgal/mile at the 1 mgd level. At the 100 mgd level the cost of the pump station is 1.7 cents/Kgal and the cost of the pipeline only about 0.1 cents/Kgal/mile. The electrical power costs are allocated to the pump station in this example.

Multi-Stage-Flash Distillation of seawater is also an alternative to wastewater renovation in communities on the sea coast. In terms of 1969 dollars, the cost of MSF distillation was given by Office of Saline Water as $1.10-$1.35 per Kgal at the 1 mgd size, 62-82 cents/Kgal at the 10 mgd size and 48-70 cents/Kgal at the 100 mgd size. Clearly, these costs are not competitive with the cost of delivered water in the Los Angeles area.

*(dollars/acre-foot)/3.26 = cents/Kgal

It should also be noted that distilled water is of very high quality; essentially no organics and about 50 mg/l of TDS. There is some possibility that if desalting is required, distilled water might be used for blending.

In Table III cost estimates for demineralization by means of ion exchange are based on the assumption that only one-half of the water will be demineralized followed with blending of the other half with the demineralized stream. Thus, the TDS of the renovated wastewater is reduced from about 1000 ppm to 500 ppm which is the limit recommended by the U.S.P.H.S. Standards.

The cost estimates for reverse osmosis shown in Table III are based on the assumption that all of the water will be treated. Thus, the water produced by reverse osmosis will be of a higher quality because of the reduced level of TDS. Logically when we compare the ion exchange train to the reverse osmosis train, we should reduce the cost of reverse osmosis water by about 3.5 cents/Kgal. This will make the reverse osmosis train look more cost-effective than the ion exchange train at all levels.

Agricultural irrigation water is normally considered acceptable when the TDS level is below 1500 ppm. Thus, disinfected secondary effluent may be adequate for some crops and if multi-media filtration is added, the water should be adequate for all crops. At the 100 mgd level, filtration and disinfection would cost only $5.54 per acre-foot. Since agricultural water is now being delivered in Southern California for $22 per acre-foot, the break-even pipeline cost would be 5.4 cents/Kgal which corresponds to a pipeline about 37 miles long.

Industrial water can be of many qualities, depending on the specific use. The treatment train shown in Table III for industrial water would cost about $21.84 per acre-foot as compared to 53 dollars an acre-foot now being charged for Colorado River water. If we reduce the $53 by the $7.56 penalty for TDS, we find that the break-even pipeline can cost $23.60 per acre-foot or 7.24 cents/Kgal. This would correspond to a 100 mgd pipeline 55 miles long.

The Department of Water and Power in the City of Los Angeles has conducted pilot plant experiments on renovating water from the Hyperion Treatment Plant. The experiments appear to show that the most cost-effective method for renovating and reusing water is to follow nitrified secondary treatment with granular carbon adsorption and disinfection. The denitrification process is expected to proceed reliably in the underground aquifer.

The cost of renovated wastewater for potable use at the 100 mgd level would cost about $87.37 per acre-foot for the 500 ppm ion exchange train and $95.51 per acre-foot for the 200 ppm reverse osmosis train. These two trains have a cost in the range of the true cost of imported Southern California water.

If the last train in Table III involving only carbon adsorption and disinfection can be used, the cost would be only $24.45 per acre-foot which is truly competitive with imported water.

In this discussion, we have not included the cost of brine disposal, assuming that the demineralization operation will be on the sea coast. If demineralization processes are used inland, the cost of brine disposal must be included in the cost of renovated water.

A study[6] of the feasibility of reuse of return flows in five Texas cities has been recently completed by the Southwest Research Institute in San Antonio, Texas. A summary of the results of this study is shown in Table IV.

Notice that the increase in TDS caused by municipal use is 400-600 ppm in the more arid cities. The demineralization costs given are for all new facilities associated with the demineralization process. These would include brine disposal and pipelines to deliver the water to the intake. Costs for demineralization were taken from OSW Report No. 555. The conveyance costs are shown separately. The treatment train assumed by Southwest Research Institute included lime clarification, ammonia stripping, filtration, granular carbon adsorption and disinfection.

TABLE IV

WATER REUSE COST AND COMPARATIVE DATA
SUMMARY FOR FIVE TEXAS CITIES
Southwest Research Institute

	Corpus Christi	El Paso	Midland	San Angelo	San Antonio
Current Fresh Water					
Average mgd	55.3	65.0	15.0	15.0	94.9
TDS, ppm	488	436	630	1253	398
Fresh Water Cost, ¢/Kgal					
Raw Water	6.0		28.0	22.0	12.5
Treated Water	10.3	15.0			
Present Wastewater Treatment					
Average mgd	10.7	15.0	4.3	5.2	86.3
TDS, ppm	1014	869	1412	1846	661
Treatment Cost, ¢/Kgal	5.1	5.4	6.9	8.7	3.7
Proposed Wastewater Treatment (secondary tertiary)					
Average mgd	14.0	26.0	6.0	7.4	100
TDS, ppm	841	716	1063	1278	393
Treatment Cost for tertiary, ¢/Kgal	28.1	24.5	36.3	33.5	18.7
Conveyance for Reuse					
Cost, ¢/Kgal	3.7	7.13	8.8	12.1	1.43
Demineralization Cost					
Electrodialysis			31.1	36.8	
Reverse Osmosis			61.7	59.4	
VCVTE	61.0	57.1	87.2	73.8	

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